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SOME MINERALS FROM MADAGASCAR AS DESCRIBED IN PROF. A. LACROIX'S *MINERALOGIE DE LA FRANCE ET SES COLONIES*[1]

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IN 1910 the distinguished professor of mineralogy at the Museum d'Histoire Naturelle in Paris completed his monumental work in four volumes, replete with drawings of crystal forms, and crowded with a mass of most carefully arranged information, covering the various developments of the mineral world in France and its colonies. The work is of vast importance, and the length of time devoted to its preparation bears witness to the thoroness and scientific perfection of the result attained. A considerable lapse of time intervened between the issue of the first three volumes, and the fourth; the remarkable mineralogic discoveries in Madagascar, especially, contributing to this delay, as their consideration rivalled in importance and in phenomenal rarity almost all the rest of the work. It is to some of the striking observations and explorations connected with this comparatively new and as yet only partially examined field of mineralogic interest that this paper briefly calls your attention, and, by reason of the minerals selected for treatment, may more particularly attract you, as it represents a field of mineralogic development allied to that wonderful Californian region so illuminatingly described by Dr. Schaller at our previous meeting.

The immense island of Madagascar lies to the eastward from Africa, at a distance of about 300 miles, separated by the Mozambique Channel from the great continent which it so closely approaches, and yet with which it seems to possess less scientific relation than with the more distant land masses of Asia. Its length is about 1,000 miles, and its mean breadth 250 miles.

[1]Read at the regular meeting of the N. Y. Mineralogical Club, Feb. 9, 1916.

From the sea on either side the land rises in terraces, attaining an altitude in some parts of 9,000 feet above the sea, and it lies between the parallels of latitude 12 and 26° S., furnishing much variety of climate. As a geological unit it presents an elevated series of north-south protaxes, with occasionally more westerly oriented mountain ranges, the whole a vast complex, largely composed of schist, with mica and feldspar as predominant constituents, with a notable frequency of biotite, and also of hornblende-gneiss, quartzite, and granulite. which have been invaded by intrusions of granite, syenite, norite, and pyroxenite. It has undergone the usual compressive strains which have, in the early ages, molded the superficial contours of the earth, and has been deeply folded, holding in the synclinals thus produced sediments which have been metamorphosed extensively, displaying broad and deep developments of calcareous schist (*cipolin* in French). Slate is also represented on the island, and with it occasional beds, perhaps referable to the Paleozoic, but apparently as yet imperfectly understood.

This complex is a highly mineralized belt, and covers the central, northern and eastern provinces, leaving a considerable but usually narrow shelf on the east. west and south, where Jura-Triassic and Cretaceous beds, Tertiary and Quaternary deposits, fill out the present outlines of the island, and whose fossil contents, congruously with the island's living fauna, suggest Asiatic affinities and antecedent connections. These later formations have also experienced the dislocation and intrusion of later irruptives, and trachyte, dolerite, rhyolite and andesite are to be numbered among the lithological features of the island.

It is the fourth volume of Professor Lacroix's monumental work which deals more particularly with the mineralogy of the island. With the above limited reference to the underlying geological features of the great island—itself most obviously, on account of the mountainous complexes it contains, a surviving portion of some greater continental development—let me transmit to you from the pages of Lacroix's exhaustive work, his observations upon some species of minerals familiar to us all, reserving perchance for some other occasion his examination and discussions of the rarer and more unusual ones.

Diopside

This mineral (so commonly represented in collections from the classic Adirondack beds), which is the usually white to

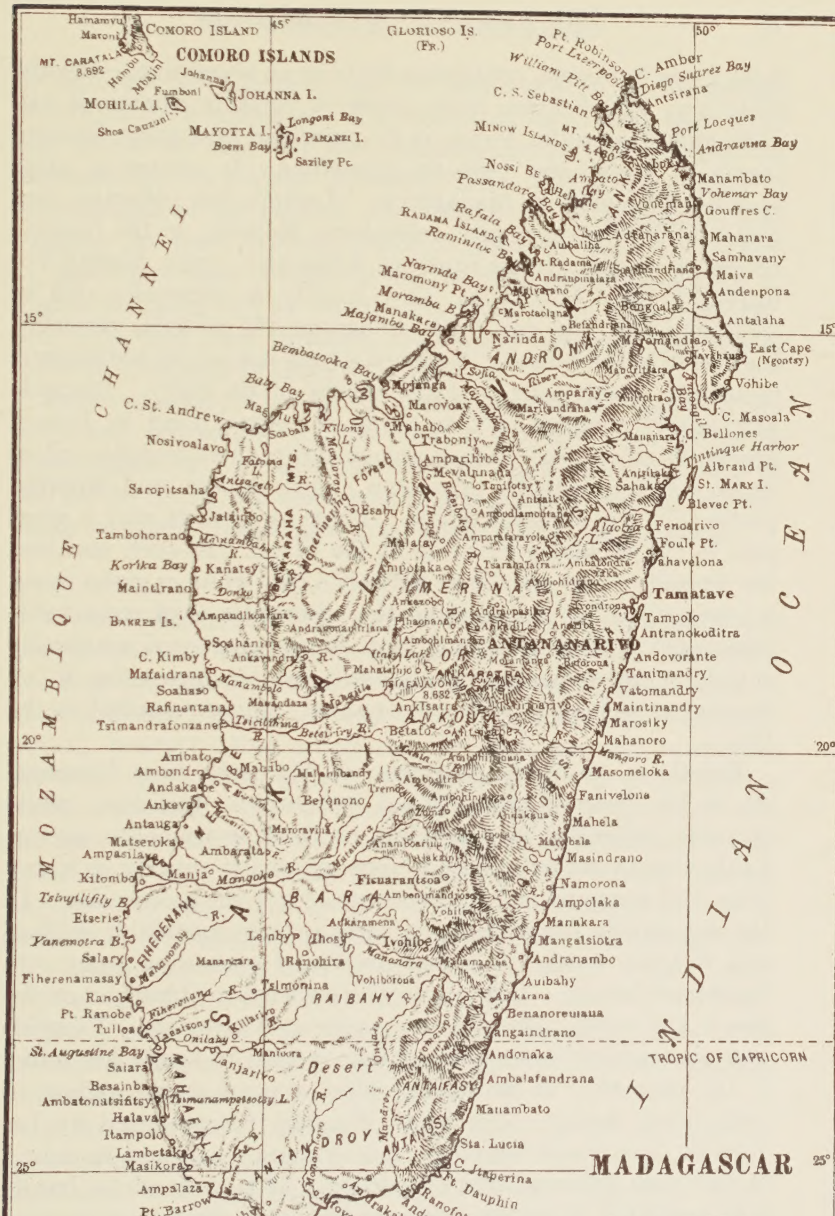


FIGURE 1.—MAP OF MADAGASCAR

Reproduced by permission from Rand-McNally's Atlas of the World

light green pyroxene, containing little or no aluminium—tho the color may also become quite dark—a variable silicate of calcium and magnesium, forms, in its purer and best color developments, a useful and pleasing gem-stone. It occurs in quite striking examples in Madagascar. Lacroix has collected very beautiful crystals of augite, resembling diopside, in the basaltic débris of volcanic cones south of Ankaratra, upon Mount Vohitromby near Antsirabe. This locality is especially rich in specimens and in a day thirty kilograms (65 pounds) rewarded the search of the collector, measuring from one to two centimeters in length (about four to eight tenths of an inch). Diopside particularly abounds in that group of rocks known to French geologists as *cipolin*,—in our nomenclature, metamorphic calcareous schists,—usually micaceous, with talcose and chloritic partings or disseminated scales. These formations play a great part in the lithologic make-up of the island. In such positions the diopside composes almost entirely a pale white or green mass, a pyroxenite. At Soavinarivo the occurrence is of remarkable persistency. Here are found large blocks composed practically entirely of the massed white diopside crystals, measuring many decimeters in length, with a prominent cleavage parallel to the base.

Elsewhere, as in the limestone of Marasaha near Voanana, which has been metamorphosed by granitic intrusions, white diopside, imbedded in pale white or blackish tremolite, occurs. In the *cipolin* are found veins made up almost entirely of microcline, but accompanied by pyroxene of a vivid green color. In the amphibolic (hornblende) granite superb crystals of diallage of a clear brownish-yellow tint are found measuring many centimeters in length. Lacroix instances a locality of interest on the bench above the palace of the queen at Tananavio. Diopside crystals ten centimeters (about four inches) in length are found in the pegmatite at Itrongahy, which assume green, yellow, or even black shades. The white diopside, characterized by Lacroix as "coarse-saccharoidal white masses," enclosed in *cipolin* of unknown origin is most interesting. It is clear white, hardly distinguishable from the calcite or limestone which accompanies it, is free from iron, and contains only slight traces of aluminium. These diopsides impregnate the amphibolic gneiss, as well as the *cipolin* of Imerina, and vary from a mineral almost free from iron to examples richly supplied with it. These latter—the

ferruginous—are found in fused or rounded crystals, resembling our Adirondack coccolite. The associated minerals in the pyroxenic gneiss are scapolite and wollastonite, and all of these are impressed by the feldspar crystallization. The effects of mineral environment in the original composition of the metamorphosed complex are here of course quite prominently shown. Lacroix in this connection comments on the frequent development of augite, diopside, etc, in furnace products, as in glass furnaces, lime kilns and blast furnaces, remarking, however, that it is a much less frequent product than fayalite.

Before passing to the especially absorbing developments of the beryl and tourmaline in this mineral Golconda, permit me to collect some of Lacroix's observations upon the occurrence of *gold* on the island; a subject which the most hardened and impregnably scientific mineralogist must admit has its fascinations.

Gold

Lacroix affirms the wide distribution of gold throughout the central axis of the island, an axis ovoidal in outline, comprising the Imerina and the Betsileo uplifts, and essentially formed of ancient primary rocks, covered or overwhelmed, and practically buried, beneath later eruptives. He indicates the auriferous nature of the bedded gravels and detritus of the rivers flowing north, west, and south. The areas most notably furnished with the precious metal are the neighborhoods of Mandritsara, the province of Boina, around Lakes Alaotia and Itasy, Imerina and Betsileo and the country of the Bares. Actual work was at first, and still largely is, confined to placer workings in the pay-dirt alluviums. The gold is found in scales of variable size, angular or rolled, and also in large nuggets. Some of the latter weighing more than one hundred grams (3 ounces) come from Mevatanana, and are of irregular outline, frequently branching and in some instances scarcely rolled.

In the province of Boina the gold is found not infrequently enclosed in quartz masses in the drift, and in such positions is associated with tourmaline of many colors, sapphire, aquamarine, zircon and garnet, the whole derived from eroded and disintegrated primary rocks. The gold is of high grade, and of a deep yellow. Betsileo comprises a number of localities and many form zonal areas dotted with exploration camps. The metal is found in the drift filling the valleys, and these secondary deposits

seem referable to the weathering of the red earths (*terres rouges*), which are themselves the result of the decomposition of amphibolic rocks. Lacroix indeed signalizes these red earths as the equivalents of the *cascajo* of Guiana. In this Betsileo region the gold is very fine. scarcely exceeding the size of a pin's head, and mingled in the alluvium rock fragments enclosing gold are encountered. There prevail in the island generally innumerable vague reports of gold being widely distributed in the mountains.

Grains of limonite, mingled with pyrite, from which the limonite has been derived, carry gold surfaces, the complex enclosed in plastic Eocene clays near Cremont, south of Epernay. Lacroix assumes a general impregnation of the crystalline schist, and of some granite, with gold, rather than its limited inclusion in quartz veins. He cites a case of a specimen of biotite gneiss saturated with native gold, around which lay the quartz. The gold was in his opinion contemporaneous with the formation of the rock itself. He instances the finding of a nugget weighing nine kilos (about 19 pounds), one of 871 grams, which however he regards as stray ingots, and not as natural specimens. But it is quite inconceivable how any one could have forgotten them!

Other occurrences present the gold in lenses of quartz and feldspar in gneiss, in mica schist, in rocks made up of kyanite and almandite; in veinlets alongside of parallel veins (themselves auriferous) and with quartz and feldspar in pyroxenic *cipolin*, in which "the gold actually plays the part of the usually disseminated metamorphic silicates"—if I have rightly interpreted the writer, a remarkable if not incredible assumption. Towards the north in a zone perhaps sixty-five miles long by three or four wide, in certain circumscribed spots, this singular disposition is found.

The sandstone and Triassic schist, more or less metamorphosed and resting on crystalline schist, contain reticulated veinlets, which instead of being formed of compact quartz, are made up of sterile quartz crystals, in rod-shaped groups, with cavities between them filled with quartz and gold. These singular cavities hold also auriferous sphalerite, chalcopyrite, argentiferous galena, and often barren centers of quartz. In the veinlets crossing the sandstone, pyrite abounds, which again contains the gold, and runs in richness from some grams to almost a kilogram per ton. Furthermore lamellar barite occurs, free from gold, except where it traverses the walls of the quartz veins. Remark-

able concentrations of gold occur here, with a record of one mass of 17 kilos (about 37 pounds) containing 13 kilos (about 28 pounds) of the pure metal. The gold yields 25-27 % of silver and is always crystallized in elongated trapezohedrons, distorted into rhombohedrons (as seen in the Oregon gold figured by Dana, *System*, Ed. 6, 15, 1892).

Lacroix, reverting to this occurrence, speaks of the quartz walls of the veins, enclosing once empty spaces, in which a microlitic deposit has accumulated. These are often divided by quartz crystals, psilomelanite, or black jasper—and in this filling sphalerite, galena, and pyrite have developed. Here occur also geodes of quartz lined with crystals of barite, chalcopyrite, and dolomite, the last having displaced calcite. The gold is in the cavities, *never* in the crystallized quartz, almost never in the barite. Lacroix claims that sphalerite was the primary mineral of the cavities of quartz, and that it held the gold, which was later liberated by some change.

Let us now pass to a subject, which, with respect to Dr. Schaller's recent lecture the N. Y. Mineralogical Club is most instructive,—the *beryl* and *tourmaline* developments in Madagascar.

Beryl

The beryl occurrences of Madagascar have assumed unusual interest from the development there of the beautiful rose-pink variety, in its gem form named morganite by Dr. Kunz. This unusual gem is shown in one specimen tonight which probably, so far as I know, is the finest example in America—a cut stone of 57 carats, exquisite in color. Lacroix has described the beryl as very common in the pegmatites of the island, where these possess highly individualized facies, namely, are very coarse. The crystals are actually colossal. Included in the feldspar and more frequently in the quartz, they are apt to be almost or entirely flawed, opaque, and more or less kaolinized, but *also* frequently affording portions intact and homogeneous, which are eagerly sought for in trade for cutting, because of their exquisite limpidity, and their beautiful color. Not infrequently these superb stones (it is understood that I am speaking now of beryl in general, not only the morganite) are frosted by innumerable liquid inclusions, in the minutest vesicles. The beryl, when kaolinized, is usually enclosed in feldspar, and can be taken

apart, in angular fragments, tho the entire crystals are more commonly imprisoned in the quartz. Lacroix enumerates colorless beryl, aquamarine, green and blue, also opaque yellow to green, accompanied by muscovite, biotite, and black tourmaline, in very quartzose pegmatite throughout the central ranges. In localities where the *cipolin* (metamorphosed calcareous schist), quartzite, and mica schist are associated, the beryl is conspicuously abundant in the veins crossing these rocks. The forms are the unmodified hexagonal prism, with the second order prism much reduced, and several pyramids. The localities which furnish commercial material are first the district of Vakinankaratra, where numerous finds have been worked, yielding pale blues, greens, deeper blues (in rose quartz), and also enormous kaolinized crystals associated with black tourmaline and muscovite. But the most remarkable locality in this district is that of Tongafeno. Here is a very coarse pegmatite, heavily packed with rose-quartz, cutting a norite rock which is itself an intrusive in mica schist. Here the beryl is found in crystals weighing many kilograms, and from these green, yellow, and bluish gems are secured, with others described by Lacroix as having a magnificent blue, tinted, he claims with black, but which is more restricted in occurrence. North-east of Betafo (after which the mineral familiar to collectors as *betafite* is named), the pegmatite yields beryl described as colored *prussian-blue*, associated with rubellite. Other localities furnish large blue crystals. Very large amounts of beryl of an asparagus-green color are taken out, with amazonite (microcline), black and violet-tinted tourmaline, though of course much, indeed the larger part, has no commercial value.

Some of the green crystals exhibit pale rose portions, perhaps not unlike the association shown tonight in a beryl section from California. South-east of Mt. Bity—a locality famous as the source of Lacroix's new mineral *bityite*—numerous localities produce huge yellow and green crystals, repeating, too, the familiar association with rose-quartz and tourmaline. Also in the district of Ambositra, crystals, variously green, blue, aquamarine, white, and amethystine, occur of great length at times, associated with blue tourmaline. Similarly the district of Fianarantosoa yields these wonderful developments of beryl. Naturally the particular interest of the mineral collector and of the gem connoisseur is fixed upon the occurrence of the un-

rivalled rose beryl, morganite. This, as is doubtless well known, is a beryl very rich in alkalies, especially in cesium and lithium, displaying remarkable refractive indices, and thereby strongly contrasted in its optical qualities with ordinary non-alkaline varieties. It is found of a peach-rose to salmon-rose color in Madagascar, at Maharitra, and Lacroix claims the demonstration of two distinct types, of identical physical appearance.

One has a density and indices of refraction very close to normal beryl, while the other is more dense and more refringent. The latter is rich in alkalies, and he naturally attributes the special properties of the beryls of Maharitra to the presence of the alkalies, and especially of cesium; which hypothesis, as many of you well know, has been confirmed by Professor Ford of Yale. Lacroix calls attention to the contrast in molecular weights of the oxides of glucinum (beryllium), of which beryl is a silicate, and which is 25.1, with the notably larger figures of lithium, sodium, potassium, cesium, which respectively are 30.0, 62.0, 94.2, and 281.6. In fact he insists that there is a graduated series of beryls, passing from minerals poor in alkalies, along an increasing proportion of these. Thus he presents a grouping of increasing density with increasing alkaline constitution, as follows:

Alkali %,	0.92;	3.29;	4.98;	6.80.
Densities,	2.716;	2.75;	2.79;	2.81.

These superb stones, outrivalling our pink beryl of California, which has never displayed the necessary depth of color for purposes of gem use, are found at Maharitra along the western slope of Mt. Bity, in veins of parti-colored tourmaline. The largest crystals exceed 20 centimeters in length (about eight inches), maintaining, almost thruout, perfect transparency. Crystals of a density of 2.75 are sometimes fissured, and are spatially transparent. The milk-white opaque portions, spotted with carmine, seem to be an older element of the pegmatite. The denser crystals are much rarer; their color is wine-rose or rose-orange, and they show the corrosions on the base. These latter are inverted hexagonal pyramids or deep grooves outlining large equilateral triangles; Lacroix suggests trigonal symmetry. These dense crystals appear to be subsequent in formation to the less dense ones. They sometimes carry sheaves of acicular tourmaline of a second generation. In some localities the clear crystals are most uncommon, and the rose beryl of the less dense

type is taken out from a kaolinized gangue in fragments more or less fissured.

In other places, outside of the Mt. Bity area, beryl has been taken in very large transparent or translucent specimens of peach-blossom-rose, particularly lovely, as at Mt. Olotsingy, south of Betafo, with rubellite, hambergite, and danburite. The crystallographic peculiarities of this rose beryl are of much interest, and will recall Penfield and Ford's observations upon the similar pink beryl of California. The hexagonal prism, as ordinarily seen in the beryl, and so customarily associated in our minds with the name of the mineral, is rare or absent, Lacroix averring that he has seen only five in which *m* was normally developed. Indeed as a general conclusion he states that the more dense rose beryl crystals are flattened parallel to the base, and show predominance of the pyramid.

Further study established the following interesting conclusions: (1) that there occurs a long series of beryls with an intergradation of densities from 2.7027 to 2.910; (2) that the series represents a progressive entrance into the beryl-formula of the alkalies, and especially of cesium; (3) that the rose color is not a necessary, albeit a habitual concomitant of the higher specific gravities; (4) that the identical localities furnish the variations indicated by the varied densities and composition; (5) that these variations may occur in one and the same crystal; thus in one, the pale green portions had a sp. gr. of 2.709 to 2.714, while the rose areas gave 2.771; (6) that the flattened form, with predominant pyramid, is characteristic of the heavier beryls; (7) that as regards occurrence, the heavier types (sp. gr. over 2.775) have only been found in pegmatite carrying lithium compounds, although such matrixes also held the varieties of low sp. gr., or even exclusively the latter; (8) that the flat form is not perhaps exclusively determined or influenced by the chemical composition, inasmuch as the high sp. gr. is in reality associated both with elongated and shortened forms, though the prevalence of the latter in connection with the alkaline beryls is unquestioned.

Finally, before leaving this most interesting subject which, in connection with the development of parti-colored tourmaline, of lepidolite, and even of kunzite, recalls the analogous developments of California, so instructively and luminously described to you last month by Dr. Schaller—may I remind you that

Professor Vernadsky of Petrograd has given the name *vorob'evite*[2] to a beryl from the Urals containing 3.10 % of cesium oxide, and 1.39 of lithia, which also had flattened crystals with prominent pyramidal faces. So that for the rose beryl, admitting that because of its high density and alkali content it is a distinct species as a mineralogical term *vorob'evite* is to be used, and morganite must be—as Lacroix assures me—applied solely as a gem name.

Tourmaline

In pursuing the interesting mineral analogies existing between the Madagascar mineral localities and those of California, this species tourmaline exacts especial attention. The tourmaline of Madagascar exhibits the whole customary range of colors, as red, violet-red, rose, yellow, blue, and green, with an arrangement of these colors in concentric zones like those of Brazil, and longitudinal alternations like those of California. In Madagascar there is a very large development of clear transparent tourmaline of gem-quality rivalling the best examples from Ceylon or Brazil, Maine or California.

The first collectors secured their specimens from river detritus, gravels and secondary accumulations of weathered rocks, and these appeared in fragments, rolled pebbles, and broken crystals. Later, with the accomplishing of the task of subduing the island by the French, the interior mining regions have become known and the original matrix of the tourmaline studied. In the district of Vakinankaratra some of the most important tourmaline developments are located, especially south of Antsinabe in the rock complex of Mt. Bity, and inasmuch as the occurrences resemble each other in the several areas where they are found, the geological conditions prevalent at Mt. Bity will serve to illustrate the rest. These pockets at Mt. Bity, also, from a mineralogical standpoint, are the richest, most complete, and most illuminating.

The formation is a micaceous quartzite, thrown up in mountain ridges, and *cipolin*, with tremolite, diopside, etc., which occupy

[2]In the original Russian the first and eighth letters of this name are *B*'s. This Russian character has the sound of English *V*, and can only be correctly transliterated to this letter in English writings. In German it is represented by *W*, in French by initial *V* and subsequent *ff*, yielding the spellings *worobewit* and *vorobiéffite* respectively. In this journal we propose to use the English form *vorob'evite*, and in the case of other Russian names to consistently transliterate into English, not French or German spellings.—The Editors.

synclinals. All have been metamorphosed by white granite veins, or dikes of pegmatite, interlaminated with the quartzite, and especially in the sediments *(cipolin)*, with a general north-south direction. In some cases these pegmatites cross the beds. The pegmatites are usually coarse, their minerals strongly individualized, tho again variable in composition with local concentrations of one or many minerals. Their striking mineralogical character arises from the alkaline nature of the feldspars —microcline, albite, oligoclase; in the abundance of the boron compounds—tourmaline, danburite, hambergite, rhodizite; their lithium contents—in lepidolite, zinnwaldite, spodumene, tourmaline, rose beryl; and their beryllium minerals, as beryl, hambergite, and bityite.

There are also found in this mineralogical profusion columbo-tantalates,—hatchettolite, microlite, etc.; phosphates—apatite; and uranium minerals, as autunite. Calcium minerals like danburite, lime garnet, and bityite seem mostly or entirely limited to the veins penetrating the calcareous beds, as a result of endomorphic change. What a foray this Club could make, under General Manchester, upon a mineral treasure-house of such dimensions and of such contents!

Some of the rock-formation is described as peculiarly beautiful, being a pegmatite made up of white albite, quartz, deep colored rubellite, and beryl of a prussian blue; an amazonite of pale blue-green with smoky quartz, rose tourmaline and striped rose lepidolite—the latter in sheets—and with it all big spessartite spheres, orange in tint, enveloped in green and blue tourmaline. How Secretary Levison would rejoice to inspect a chemical chaos like that! But again the story becomes almost fabulous; the veins contain enormous geodes, vast pockets of crystals, where the glorious contents are scattered about with a careless hand, now here now there, and where, too, neighboring apartments furnish the rich druses made up of different minerals.

Kaolinization is prevalent in the feldspars, and crystallographic perfection is sacrificed, while the various contents appear on the surface from this general or deep-lying decomposition. Here the tourmalines lie about in fragments, and it was from these surface-finds that the first examples were gathered. Elsewhere beryl and spodumene are pulled out of the clay-alterations with brilliant surfaces, but more or less deeply pitted by corrosion. Lacroix especially signalizes the enormous scale of de-

velopment of most of the minerals both in the druses and in the common composition of the pegmatite. The veins of the pegmatite are sometimes very numerous in one formation, and the mineralization presents sharp contrasts from one to another To illustrate, our distinguished author takes two localities which may be thus briefly summarized. At Maharitra a pegmatite lies in the *cipolin.* It extends four hundred meters (some thirteen hundred feet). It is coarse, full of cavities, rich in big smoky quartz, microcline, black and parti-colored tourmaline. The crystals of the last have clear colors, are zoned and finely terminated. One geode yielded 16 kilos (about 33 pounds) of rubellite.

Again beryl of various colors occurs, particularly the beautiful peach-blossom-rose *vorob'evite,* with lepidolite, garnet, danburite, hambergite, spodumene, bityite, while magnificent crystals of rubellite swell the monstrous show into a fabled dream of Vathek or the Arabian Nights. Further west a finer pegmatite enclosed in mica schist contains principally rubellite, sparsely developed, and eight hundred meters (nearly half a mile) to the north, a similar vein holds sky-blue and green beryl. Elsewhere too, coarse pegmatite holds much fissured and poor tourmaline, enclosed in smoky quartz. Again to the north-east another vein has the tourmaline in long olive-green blades, shut up in white quartz, and near at hand very quartziferous pegmatite, rose-tinted, holds black tourmaline.

Some of the veins have been followed for long distances, and veins at Antandrakornby have yielded splendid rubellites of a dark red, frequently developed into bipyramidal crystals, while against the limestone green-blue indicolite spreads its exhilirating contrasts. Spodumene is concentrated upon the edges of the veins, in which are embedded crystals of rhodizite. Surely here are questions of genesis, paragenesis, and everything else mineralogenetic for Mr. Allen to set to-rights for us all.

Lacroix was of course particularly interested in the parti-colored tourmaline. It appears that these superb crystals—homogeneous and transparent—formed the immediate incitement for the mining of these extraordinary mineral deposits. We are told of a rubellite from Maharitra weighing about thirteen pounds and measuring some fifteen inches in length and almost four inches in width. And—tell it not at Trenton, Dover, Boston, or even Franklin Furnace—there are larger ones!

Lacroix avers seeing a crystal extracted from near Betafo which attained the weight of over thirty pounds.

Our author notes the deficiency in terminal forms, and their general poverty of faces. You know that the antilogous pole of tourmaline is usually quite rich in faces. In these Madagascar localities the analogous pole is attached, and the antilogous is free, and its development may have been too rapid for the growth of a multiplicity of faces. Doubly terminated crystals seem exceptional, in contrast to their comparative frequency in California. The face $e^{\frac{1}{2}}$, a "rhombohedral" face—is not common, but when found occurs in brilliant facets, upon beautiful deep-green crystals.

The e_2 faces, also "rhombohedral," are generally dull in the crystals described by Lacroix, and their development is an incident of locality. Thus in the valley of Sahatany they are not commonly found, but in the crystals from Betafo, or its neighborhood, they are well developed. The rubellite from Ampasihiatra varies from a regular to an irregular development of faces. Not infrequently its crystals are flattened upon the e^2 face (prismatic), which produces distortion in the faces of the apex. Usually the development involves wide and predominant e^1 faces, with narrow p faces, and a very minute base c. Crystals of a pale color, which are abundant at Maharitra, are usually more regular, although here anomalous developments take place also, presenting a monoclinic aspect. (Cf. Plate II).

The tourmaline is extremely variable in color, not only in individuals from the same pocket, but in the same crystal, a fact certainly familiar to the collectors of Californian tourmaline. Rubellite of a deep red does not maintain homogeneity of color throughout, while some, most interestingly, present the appearance of aventurine, due to the numerous inclusions of lepidolite. Naturally, as we know in our own examples, the same crystal is parti-colored, displaying, according to Lacroix, a very notable range of color variation, from red, through yellow, brown, orange green, to blue and gray, or even losing all color, and terminating the series with pure limpidity.

Lacroix has studied these variations in the tourmaline colorations, with a view to coördinate them or classify them as systematic phenomena. First there is the variable coloration in the axial direction of the crystal, which he considers related to its hemimorphic habit, and one of the instances most frequently

seen is that in which the antilogous pole, terminated by e^1, is green, and the analogous pole, by which the crystals are attached to their gangue, is rose. The transition in color may be abrupt or gradual. The intergradation of tints may be most extraordinarily multiplied. A group of large crystals, composing an assemblage of 20 individuals, presented throughout the same peculiarities—the apexes were copper red, then followed the interposition of several colorations of unequal lengths, blue, green, gray-rose, deep blue, red. Again this is varied by the development throughout the body of the crystal of one tint, with the terminal faces of a different color. These aspects, though perhaps not so spectacularly illustrated, are familiar of course to American collectors.

Lacroix's second group is that of the concentric disposition of the color, not perhaps so frequently seen in our American examples of the chromatic tourmaline, but actually well known. Thus a deep red center is surrounded by an outer yellow envelope, or it may be green, as a simple and most common arrangement. It is rare to have the red color exterior. These concentric zones may be very numerous, with a repetition of the colors, all of the concentric envelopes having the same form. But, if conditions in the crystallization have varied in the growth of the crystal, the zones assume different outlines; for instance they may be triangular in the center, and hexagonal outward from that. Lacroix instances, as a rarity, a deep violet central triangle, enveloped in a hexagon of the same color, but clearer, it again enfolded in a green hexagonal prism. If crystals of this character have a distinct termination the apical rhombohedron may have sometimes the color of the exterior envelope, sometimes that of the center. As our author writes he says: "I have in my hand a crystal, zoned a rose and a pale green, of which the center is a homogeneous rose in one part of the length of the crystal, while in another part the center has been occupied by a deep green rhombohedron, easy to study from a plate 8 mm. in thickness, and the section is triangular."

He points out the existence of rod ("bacillary") crystals of a complex structure, formed by the cementation together of parallel individuals, originally separate, and of the same color, and later soldered together, as it were, into one and the same crystal, by the addition of material of a different color.

Again the crystal grows by alternating deposits upon the faces of a terminal rhombohedron, which results in triangular outlines in the transverse sections. The transition from zone to zone may be gradual and the changes then appear delicate and scarcely susceptible of distinct determination, but if the crystal has grown very slowly, with sharp alternations in the composition of its accretions, there results a series of triangular bands, well defined in a triangular *marqueterie*.

More oddly, in some triangular sections red lines, boundaries of formative crystals, intersect at the center at an angle of 120 degrees, or, there has taken place a regular grouping of three crystals, each *two* furnishing *one face* of the final crystal, on one side of the last triangle, by confluence. With the assemblage thus formed, if we imagine that the planes of contact within the triangle of these three crystals are colored red, the peculiar appearance of the transverse section is explained.

Lacroix records the great frequency of limpid crystals, of which the opaque rhombohedral faces are brilliant. Again a cylindrical habit or structure has been observed, and, as frequent also, a fibrous structure, where the striated portions are found only in a small portion of the crystal, usually situated at the intersection of the apex with the prism. Tourmaline crystals in these Madagascar pockets have been broken by earth movements, and mended by new accessions of the surrounding minerals, precisely as in specimens we are familiar with, in the U. S. Lacroix has detected in the fragments of a crystal, deep green along the vertical axis and a dull violet across it, slightly flattened globules, and upon the flattened surfaces—flattened parallel to the base—he discovered three series of grooves (*cannelures*), uniting at the center, which he regards naturally as the rhombohedral edges, and which form three triangular sections with a curved surface. These perlitic globules were obtained upon breaking the upper end of a large crystal.

Two generations of tourmaline were determined to exist in the geodes or pockets of Maharitra. The most recent consist of very pale rose needles, with yellow or colorless exteriors, and perfectly limpid. They formed delicate shrubby growths upon the longer crystals, or upon the drusy crystals of the rose beryl. Has not a similar association with the rose beryl of California been noticed?

Spodumene

It is a matter of extreme interest in connection with the finding of these beryl and tourmaline occurrences, so sharply suggesting similar mineralizing forces, as functioning both in California and in Madagascar, to learn also that the beautiful rose *spodumene* (triphane of the French mineralogies) and known familiarly here under the name of *kunzite* is found in similar associations in Madagascar.

The spodumene is found in Madagascar under two aspects. Large crystals, rose or green, stony, also translucent, but with the color poorly developed, and generally translucent only in thin sheets, are found in the pegmatite of Antandrokomby, associated with quartz, microcline, albite, and tourmaline, enclosing at times crystals of microlite and rhodizite.

Spodumene quite clear, colorless, greenish yellow, or sometimes rose, is found in the pegmatites of Maharitra, but the form *kunzite* occurs only in the neighboring quarry of Ampasihiatra. The crystals may be from three to four inches in length, embedded in a kaolin of decomposition, which forms the gangue. They are usually parted by the easy cleavage, and more or less profoundly pitted, by cavities of erosion. They are referable to two forms; one of elongated character in the direction of the vertical axis, and the other shortened, and almost universally exhibiting no other crystalline planes than the *prism*. Spodumene is also found in the vicinity of Betafo with beryl, hambergite, and tourmaline.

In two analyses made by the Genevese chemists the percentage of lithium oxide was 3.76 and 4.02. The occurrence of this rose spodumene was for some time doubted, and the developments have not yet rivalled the extraordinary instance of its crystallization, as seen in the pocket discovered some years ago in California, which contained some five or six crystals of phenomenal size, two of which form today one of the most conspicuous ornaments of the gem collection of our museum, in the famous Morgan cabinet.

Genevese chemists have published analyses, showing that the tourmalines here considered are more rich in sodium than in lithium, that the red and rose minerals are more calcic, and less manganesic, than the yellow, the brown, or the green ones. As is well known the black are highly ferriferous, but these are also rich in manganese. The table of the analyses is interesting in

the variations of the elements shown in the different colored stones.

Black crystals of tourmaline are not found well developed at the localities where the gem stones are found, but occur elsewhere in Madagascar, in crystals of much beauty and of very considerable size.

Thanking you for the privilege of presenting this paper on a subject, which properly illustrated with specimens, would prove to be, I think, one of the most stimulating of mineralogic themes, I can only, through the courtesy of the Museum, show some of the very fine specimens we possess.

REVIEWS AND ABSTRACTS

EDGAR T. WHERRY

A new edition of Clarke's Data of Geochemistry has appeared as U. S. Geological Survey Bulletin 616. This book contains a most valuable critical summary of our knowledge of the chemistry and the genesis of minerals and rocks.

ÜBER KRYSTALLSTRUKTUR (CRYSTAL STRUCTURE). A. Schoenflies, Frankfurt a. M. *Z. Kryst. Min.* **55,** 4, 321–352, 1916.

A technical, mathematical discussion.

ÜBER DAS TONMINERAL MONTMORILLONIT UND DAS TONERDEPHOSPHAT PLANERIT (THE CLAY MINERAL, MONTMORILLONITE, AND THE ALUMINIUM PHOSPHATE, PLANERITE). Hans Leitmeier, of Doelter's Mineralogical Institute, University of Vienna. *Z. Kryst. Min.* **55,** 4, 353–371, 1916.

A clay is described which was amorphous and colloidal when found but on standing in the laboratory three years became crystalline. It is believed to be a definite chemical compound of the formula $Al_2Si_4O_{11}+6H_2O$. [The name cimolite has priority over montmorillonite. Editor.]

A white to blue aluminium phosphate is described in detail and regarded as the gel (colloid) form of planerite. As found it contains twice as much water as does this mineral, but half of the water is driven off below 100°, and is not included in the formula, which is given as $H_{36}Al_6P_4O_{37}$. The blue color of some

specimens is due to a copper compound, and in order to determine in what form this is present L. placed some of the white mineral on a filter and poured copper-ammonia sulfate solution over it until the filtrate became blue. Analysis then showed that 5.8% CuO had been taken up by the phosphate. He accordingly concludes that the copper in this and other similar minerals is not chemically combined, in any definite compound, but is held by adsorption [the phenomenon shown by colloidal substances of uniting with other substances by surface attraction instead of chemical affinity]. Planerite is regarded as identical with ceruleolactite. [This identity may be questioned, as ceruleolactite from Gen. Trimble's iron mine, Chester County, Pa., is distinct from planerite in its optical and many other properties. Further it must be pointed out that water which escapes from a mineral, and especially from a colloid one, below 100°, is not necessarily different from that held to a higher temperature; much depends on the state of division of the material, the dryness of the air when the analysis is made, etc. If all the water is included, L.'s mineral is identical with vashegyite, which was described by Zimanyi in 1909 and has recently been reported from an American locality (Abstr. in *Am. Min.* **1,** 1, 18, 1916). EDITOR.]

ÜBER DAS VORKOMMEN DER BASISFLÄCHE AM QUARZ (THE OCCURRENCE OF THE BASAL PLANE ON QUARTZ). H. STEINMETZ, of Munich. *Z. Kryst. Min.* **55,** 4, 376–377, 1916.

The three previously reported occurrences of this face are noted, and a new one from the Simplon Tunnel described. The face is very poor, and its identity could be determined only by study on the reflecting goniometer.

THE LOZENGE-SHAPED CAVITIES IN THE FIRST WATCHUNG MOUNTAIN ZEOLITE DEPOSITS. EDGAR T. WHERRY, of the U. S. National Museum. *J. Wash. Acad. Sci.* **6,** 7, 181–184, 1916.

It is shown that the crystallographic, geologic and genetic evidences all agree in indicating the original mineral of these familiar objects to have been glauberite, $Na_2Ca(SO_4)_2$.

EXCHANGES OFFERED

Exchange notices will be printed free of charge to our subscribers in this column. Goods for sale must be offered in the advertizing columns.

A. J. Rice, 1041 Wood St., Easton, Pa. Verdolite, asbestos, noble serpentine, rose calcite, talc, biotite, blue limestone, chrysotile, pyrite.

Roy Carson, 380 S. Chester Ave., Pasadena, Cal. Beach stones, polished or unpolished, including chalcedony (California moonstone), jasper of various colors, agate, serpentine, etc.

W. Scott Lewis, 3493 Eagle St., Los Angeles, Cal. Desert jasper, chalcedony (fine for cutting); rare forms of petrified wood, asphaltum from La Brea fossil beds; shell limestone; biotite, and miscellaneous common minerals.

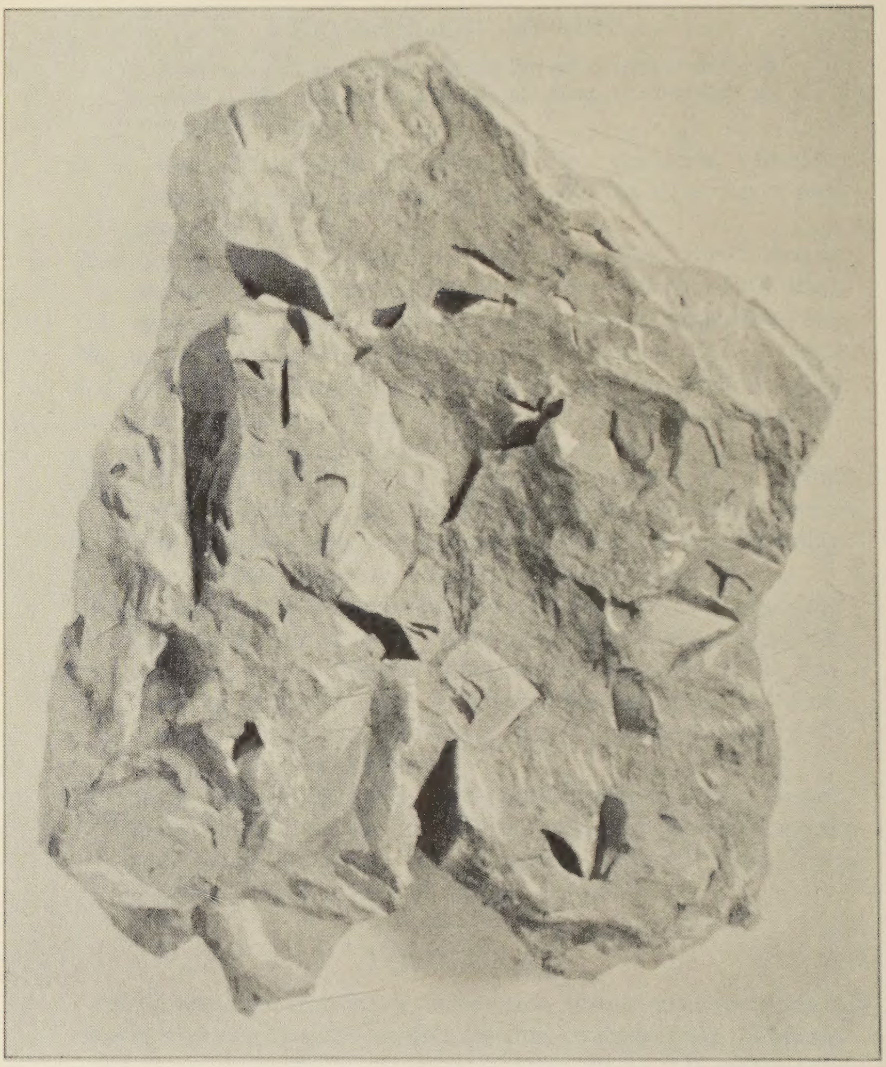
Wm. H. Broadwell, 571 Hawthorne Ave., Newark, N. J. New Jersey zeolites (Apophyllite, laumontite, natrolite, pectolite, prehnite, etc.); thaumasite, babingtonite; rhodonite, franklinite, zincite, etc. List sent upon application.

W. G. Levison, 1435 Pacific St., Brooklyn, N. Y., will exchange fine specimens of New Jersey minerals or some duplicate numbers of the Mineral Collector, for any parts of the Proceedings of the Lyceum of Natural History of N. Y., Series 1 and 2, or any parts of Vols. 1, 2 and 3 of the Annals of the N. Y. Acad. of Sciences.

Edwin A. Turner, 1696 Green St., San Francisco, Cal. Jasper, green chert, cinnabar, kinradeite (spherulite jasper) chalcedony from Culebra Cut, Panama; opalized wood from Nevada; beach stones of various colors.

CORRECTION

A LITERALLY translated instruction sheet accompanying a chemical balance introduced into this country from Germany several years ago stated, concerning other styles, "In spite of the most carefulness the rider *will* fall." In apologizing to the readers of this magazine for the necessity of correcting an error of unfathomable origin in the first number, the editors can only say that altho we have exercised and will continue to exercise "the most carefulness" in proof-reading, errors *will* escape notice occasionally. On page 7 of our July number in text line 7, 47 should read 46; and toward the lower right hand corner of table II, on the same page, the lower letter I should be omitted.



Photograph by U. S. National Museum

GLAUBERITE CRYSTAL-CAVITIES IN TRIASSIC SHALE,
STEINSBURG, BUCKS CO., PA. (×½)

PLATE III